

Contract No. R-032-041
“Portable Solar Array Modules”
Submitted by Packet Digital
Principal Investigator: Andrew Paulsen

PARTICIPANTS

Sponsor	Cost Share	
U.S. Naval Research Laboratory	\$425,000	
Nishati Solar Power	<u>\$ 75,000</u>	
Subtotal Cash Cost Share		\$500,000
North Dakota Industrial Commission	<u>\$500,000</u>	
Total Project Cost		\$1,000,000

Project Schedule – 9 months	Project Deliverables:
Contract Date – 4/18/2018	Progress Report: 5/1/2018 ✓
Start Date – 2/1/2018	Progress Report: 8/1/2018 ✓
Completion Date – 1/1/2019	Progress Report: 11/1/2018 ✓
	Final Report: 4/1/2019* ✓

OBJECTIVE/STATEMENT OF WORK:

The purpose of this project is to develop and commercialize transportable solar power generation modules capable of delivering up to 1kW for remote military installations, emergency shelters and camps, and a variety of commercial uses; and to eliminate the fuel requirement and noise and reduce the life cycle cost of standard electromechanical power generation.

Packet Digital is partnering with Nishati, a Virginia based company to develop the product. Manufacturing will occur at Chiptronics in Dunseith, North Dakota. Navigant Research forecasts the portable solar market will grow from \$550 million in 2014 to \$2.4 billion in 2024 (15.87% CAGR.) The product that Packet Digital is developing is expected to provide portable solar with 36% more power in 42% less space and 80% less setup time compared to what is currently available on the market.

STATUS:

The contract has been executed.

May 1, 2018 status report received. The report states in part:

Significant progress has been made thus far on the project. Both inverter and battery market research has been completed. Several viable options are available depending on the end customer’s requirements. Solar panel simulation models have also been created that will enable system configurations to be evaluated prior to physically constructing the systems. The groundwork has now been laid to begin prototyping the system.

Additional details are available in the full report.

August 1, 2018 status report received. The report states in part:

Significant progress has been made on this project, primarily focusing on market research requirements capture, and system architecture.

- Objective 1&2 for inverters and batteries evaluation are completed (see Interim I report).
- Market research for military and commercial requirements capture initiated.
- Evaluation of solar panel configurations for MPPT was completed and a preferred configuration was designed and its performance was simulated. The system leverages the existing, field proven, Nishati panels and enclosure.

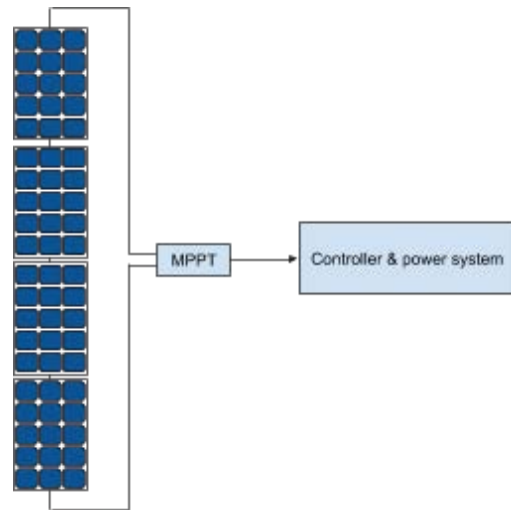


Figure 1: Selected solar panel configuration for MPPT

- Expedition 570 solar panel modelling for power simulation and analysis of the selected configuration.
- High level architecture of the system was defined, as shown in Appendix A. This architecture accommodates the system performance and features needed for the US military application, which is the most stringent application. The architecture defines the logic blocks of the system, such as integrated battery chargers, USB charging ports, a power sharing port, a main controller, and a maximum power point tracker.
- Additional hardware development identified such as bidirectional buck/boost power converters, USB charger, firmware update support, and communication with smart batteries.
- Electronic hardware design initiated and some components have been ordered to facilitate prototyping.
- Initial space claim analysis was performed to determine the possible locations and size of the electronics enclosure and battery trays. Several areas in the enclosure were identified as possible locations for the electronics, primarily consisting of the thin area between the panel and the enclosure when stowed. This will be further refined in the next interim as electrical and mechanical design progresses.
- A cooperative research and development agreement (CRADA) with the U.S. Naval Research Laboratory has been negotiated and completed. This agreement formalizes the partnership and roles of Packet Digital and NRL.

Additional details are available in the full report.

November 2018 – Status report received. The report states in part:

- Objective 3 for MPPT modification is completed, objective 4 for additional hardware, custom enclosures and transport cases evaluation and development is in progress.
- Modification implemented on the high-level architecture to better fit the applications. The changes are to allow the solar panels to be disconnected from the electronics for direct connection with external legacy US military MPPT controller. The updated architecture still supports integrated battery chargers, USB charging ports, a power sharing port, a main controller, and a maximum power point tracker.
- Nonoperational mechanical model of Expedition 570 solar panel has been received by Packet Digital and being used for mechanical fit and test of the electronics module. This mechanical model accommodates the discussion between Packet Digital and Nishati regarding the overall layout design and placement of the electronics module and interface.
- Previously identified hardware developments such as bidirectional buck/boost power converters, USB charger, firmware update support, and communication with smart batteries have completed schematic design stage and moving into PCB layout design state.
- Space claim analysis is complete, locations and size of the electronics enclosure and battery trays have been identified and decided. This may be further refined in the next interim as mechanical design progresses.
- Overall solar generation system layout with electronics module placement location within the solar panel fixture has been discussed, identified, and decided.

January 2019 – The recipient has requested and been granted a no-cost extension through April 1, 2019.

March 2019 – Status report received. The report states in part:

- First revision of the power electronics PCB assembly stage is complete. Tests revealed several issues that necessitates design modification which were implemented in the second revision of PCB assembly. This second revision of PCB assembly is in progress.
- First revision of the MPPT PCB assembly is complete. MPPT algorithm tested and verified. Further tests under various operation conditions including field tests revealed several issues that necessitates design modification which were implemented in the second revision of PCB assembly. This second revision of PCB assembly is in progress.
- Custom enclosure design for individual electronic components and integrated system has been finalized and fabrication is in progress.
- Final documentation of system testing is pending system test completion. Internal documentation is in progress as the system is being tested and optimizations are being done.
- Transition to manufacturing readiness is pending system test and verification
- Commercialization partner and distribution have been identified (Nishati), further determination is pending upon the completion of system test and verification.

Additional details are available in the full report.

May 2019 – Final report received. The report states in part:

- Power electronics and hardware for a portable 1kW solar power system, including 1kW inverter, smart batteries, and MPPT
 - Design and construction of PSG1 with integrated MPPT.
 - Construction of PSG-C1000, incorporating 1kW inverter.

- Identification and use of military smart battery BB2590 in the system.
- Innovative MPPT algorithm for extracting maximum charging capacity from the solar cells
 - Greater than 97% efficient MPPT algorithm with rapid convergence.
- Custom enclosures for individual electronic components and integrated system
 - Aluminum backplate and UHMW front plate for PSG1 electronics, custom designed to perfectly fit into the Expedition 570 solar panel case.
- Documented results of system testing
 - Successful laboratory and field tests of the portable solar system.
 - Datasheet creation for PSG1 and PSG-C1000
- Manufacturing ready for a commercially viable, portable 1kW solar power system
 - Manufacturing ready prototypes for PSG1 and PSG-C1000 have been built.
 - Expedition 570 solar panel is available through Nishati and is manufacturing ready.
- Commercialization partners and distribution
 - Nishati will be our commercial partner and distributor.

More details are available in the full report and final summary. This contract is now closed.

Updated 5/21/19

*Denotes change from original contract.